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## A New Species of the Family Bythograeidae (Crustacea, Decapoda, Brachyura) from the Hydrothermal Vents along Volcanic Front of the Philippine Sea Plate

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**Abstract** A new bythograeid crab named *Austinograea yunohana* is described on the specimens from some hydrothermal vents along volcanic front of the eastern edge of the Philippine Sea Plate, off central Japan, as the ninth of the family Bythograeidae Williams, 1980, and the third of the genus *Austinograea* Hessler et Martin, 1989. The new species is most closely related to *A. alayseae* Guinot from the South Pacific, but remarkably different in having the filiform second male pleopod nearly as long as the first.

**Key words:** Bythograeidae, new species, *Austinograea*, Northwest Pacific, central Japan.

### Introduction

Since the description of *Bythograea thermydron* Williams, 1980 from the hydrothermal vents on the Galapagos Rift as the representative of new genus, new family and new superfamily, seven species referred to three genera were added to the family Bythograeidae. They are *Bythograea microps* and *Cyanograea praedator* described by de Saint Laurent (1984) from the East Pacific, *B. mesatlantica* Williams, 1988 from the Central Atlantic which was later designated as the type species of the genus *Segonzacia* erected by Guinot (1989), *B. intermedia* de Saint Laurent, 1988 from the East Pacific, *Austinograea williamsi* Hessler et Martin, 1989 from the West Pacific, *A. alayseae* Guinot, 1990 from the South Pacific, and *B. laubieri* Guinot et Segonzac, 1997 from the East Pacific. These species inhabiting the active hydrothermal vent sites are characteristic in having the whitish carapace, with the degenerate

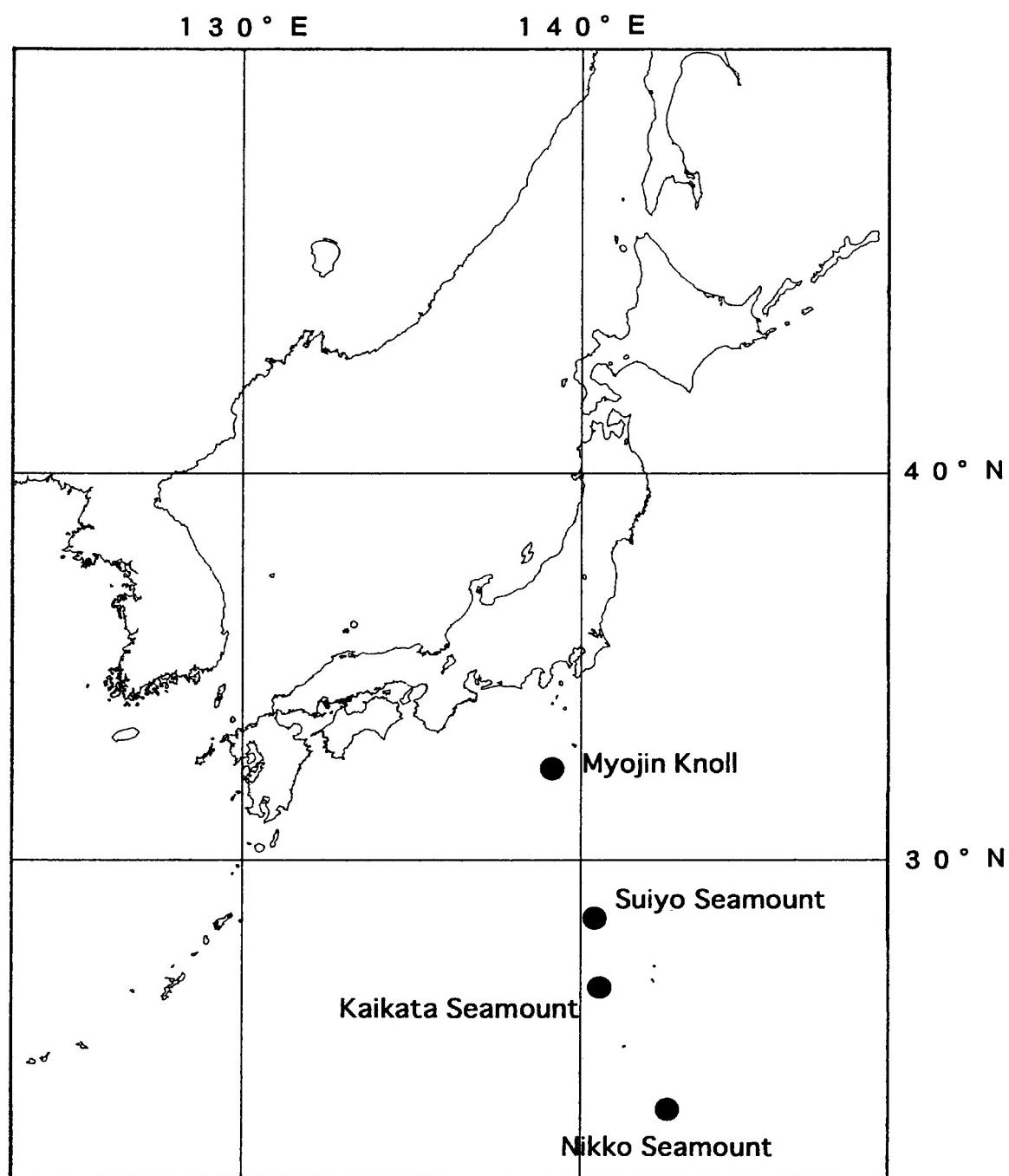


Fig. 1. Map showing the localities of *Austinograea yunohana* sp. nov., along the volcanic front of the Philippine Sea Plate.

eyes and eyestalks to variable degrees.

During a long series of deep-sea surveys at the hydrothermal vents along volcanic front of eastern edge of the Philippine Sea Plate, off central Japan (Fig. 1), by a deep-tow TV system and the manned submersibles *Shinkai 2000* and *Shinkai 6500* of

the Japan Marine Science Technology Center (JAMSTEC), the bythograeid crabs living in high densities were commonly observed (Fig. 5B), and then captured for taxonomic and biological studies. In this paper, these crabs are to be described as the representatives of a new species of the genus *Austinograea* erected by Hessler and Martin (1989).

The holotype, allotype and some representative paratypes, and also some young specimens are preserved in the National Science Museum, Tokyo (NSMT), and one of the paratype females is retained by the Japan Marine Science and Technology Center (JAMSTEC). Otherwise, some paratypes will be sent to the Natural History Museum, London (NHML), the Muséum National d'Histoire Naturelle, Paris (MNHN), the Nationaal Natuurhistorisch Museum, Leiden (NNML), the Nature-Museum und Forschungsinstitut Senckenberg, Frankfurt a.M. (NMFS), and the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

### Description

#### *Austinograea yunohana* sp. nov.

(Figs. 2-5)

*Type material.* **Myojin Knoll**—*Shinkai 2000* dive #1007 (32°06.19'N, 139°52.04'E, 1,263 m deep), 2♂♂ (paratype, MNHN, 38.0×24.9 mm; holotype, NSMT-Cr 13655, 41.9×26.9 mm), May 5, 1998. **Suiyo Seamount**—*Shinkai 2000* dive #626 (28°34.50'N, 140°38.50'E, 1,380 m deep), 2♀♀ (paratype, JAMSTEC, 38.3×25.2 mm; allotype, NSMT-Cr 13656, 50.5×32.5 mm), July 11, 1992. **Kaikata Seamount**—*Kaiyo* cruise DK88-3-IZU (26°42.60'N, 141°04.60'E, 420–450 m deep), 2♂♂ (paratypes, NSMT-Cr 13657, 20.6×13.6 mm; 27.0×17.5 mm), 2♀♀ (paratypes, NSMT-Cr 13658, 31.5×20.5 mm; 34.4×22.4 mm), Aug. 31, 1988, by a small dredge hanging on deep-tow TV system; *Shinkai 2000* dive #1014 (26°42.35'N, 141°04.67'E), 448 m deep; 2♂♂ (paratypes, USNM, 28.0×18.8 mm; NSMT-Cr 13659, 33.8×21.9 mm), May 18, 1998. **Nikko Seamount**—*Shinkai 6500* dive #144 (23°04.70'N, 142°19.90'E, 433–762 m deep), 1♂ (paratype, NMFS, 32.5×21.2 mm), 2♀♀ (paratypes, NSMT-Cr 13660, 31.6×20.6 mm; NHML, 37.4×25.2 mm), Sept. 19, 1992.

*Additional material.* Kaikata Seamount, 11♂♂ (5.4×4.0 mm—17.3×11.7 mm), 1♀ (12.4×8.6 mm) (NSMT-Cr 13661), data same as *Kaiyo* cruise DK88-3-IZU.

*Description of holotype* (Male: Figs. 2, 4G–I). Carapace 41.9 mm in breadth (cb), 26.9 mm in length (cl). Carapace elliptical, with ratio of length to breadth (cl/cb) being 0.64, weakly and evenly curving downward to frontorbital margin, nearly flat toward lateral margins of both sides; each posterolateral part weakly concave along margin; dorsal surface of carapace smooth and shining to naked eye, without hairs or setae, but microscopically roughened with numerous minute punctae for its

most part and with obtuse scaly granules along frontorbital and anterolateral margins; regions ill-defined, only with a median, longitudinal bifurcating furrow subdividing gastric regions into proto- and mesogastric subregions; branchial and cardiac regions hardly traceable.

Front nearly truncated, not protruded from general outline of carapace, about a quarter as wide as carapace; frontal margin separated into two weakly convex lobes, studded with pearly granules, having a small median lobule instead of notch; lateral part of each lobe not produced, confluent with supraorbital margin without interruption. Supraorbital margin shallowly concave in dorsal view, distinct along its inner oblique part, faded out laterally toward anterolateral margin of carapace, without external angle.

Orbit shallow, widely open, with small eyestalk fixed at its bottom; anterior part of orbital floor nearly vertical from supraorbital margin, posterior part flattened, twice as long as anterior part, inclined to pterygostomian region. Eyestalk immovable, thickened distally, with distal part truncated together with unpigmented cornea; its ventral surface truncated so as to be flattened against antennal basal segments.

Third maxilliped covered with small dispersed depressions filled with setae; ischium twice as long as merus, twice as wide as exopod with a longitudinal furrow along its inner margin; small area of proximal part of coxa exposed as part of sternal surface, coxal lateral projection being entirely inserted into gill chamber; distal half of inner margin of merus shallowly concave; propodus and dactylus with brush-like fringe of dense setae along their inner margins; propodus about two thirds as long as slender club-shaped dactylus.

Anterolateral margin of carapace strongly arched, sharply edged throughout its whole length, without distinct interruptions or depressions. Posterolateral margin rather strongly convergent, shallowly but distinctly concave for its main part; its posterior part strongly concave just above coxa of last ambulatory leg. True posterior margin of carapace as long as frontal margin, shallowly concave along first abdominal segment.

Both chelipeds heavy, long, slightly different in size and shape, with the right being larger; merus elongated, beyond anterolateral margin of carapace by its distal half; upper surface shallowly excavated for its most part, with anterior margin thickened and fringed with pearly granules of good size; posterior margin thickened along its proximal half, rounded along distal half and extended onto upper surface to make an appearance of swollen skin; distal end of anterior margin distinctly angulated; carpus comparatively large, rounded as a whole, without inner angle; carpus and palm seemingly smooth, with microscopical pits and depressions; palm strongly inflated at basal part of its inner surface in both chelipeds; top of each inflation angulated toward base of palm, with cluster of some granules; outer surface of palm smooth and regularly convex; fingers strong, one and half as long as palm in smaller chela, slightly longer than palm in larger chela, with dark-colored distal halves; both fingers of

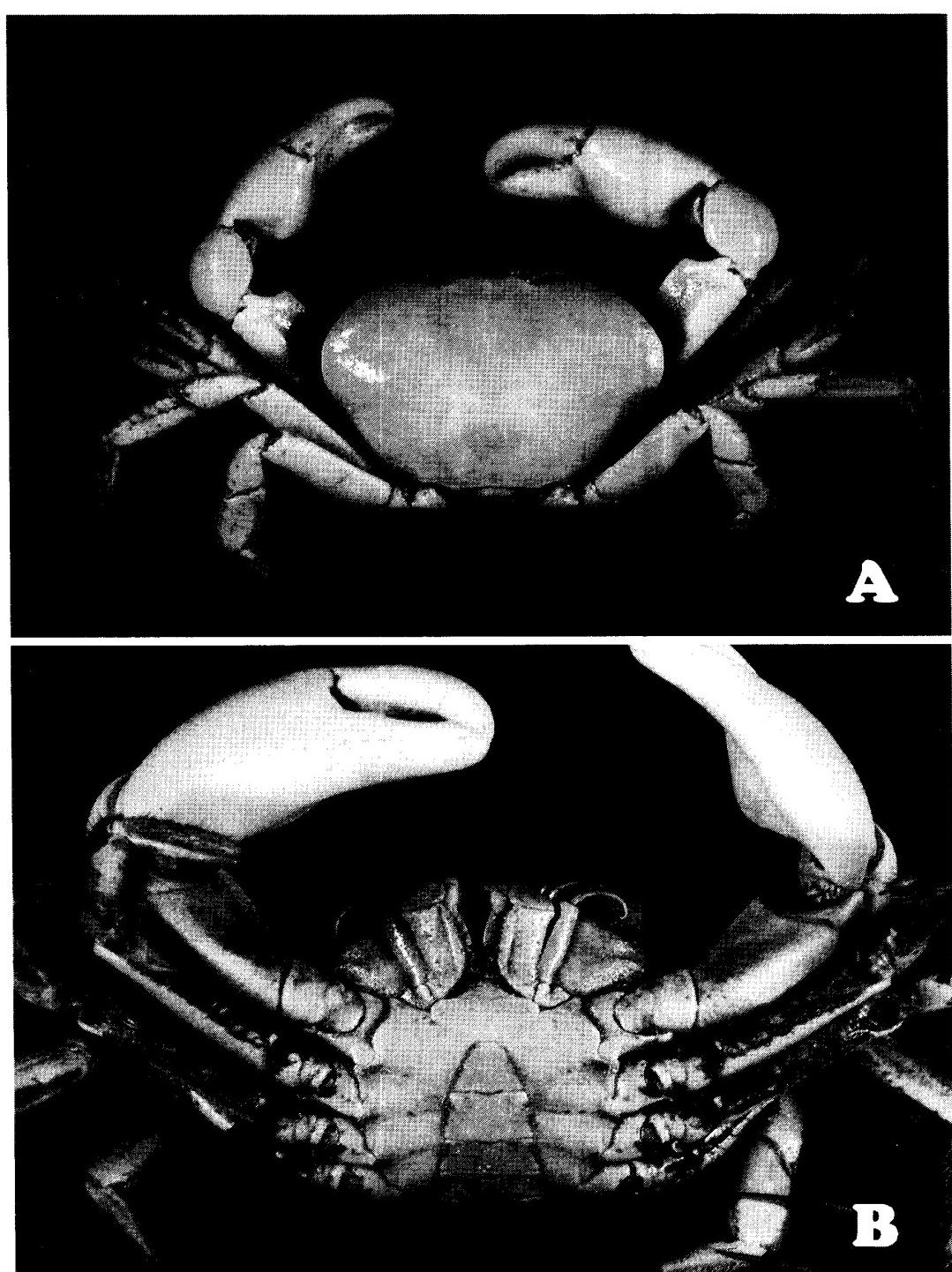


Fig. 2. *Austinograea yunohana* sp. nov., ♂ from Myojin Knoll (holotype, NSMT-Cr 13655; 41.9×26.9 mm) in dorsal (A) and ventral (B) views.

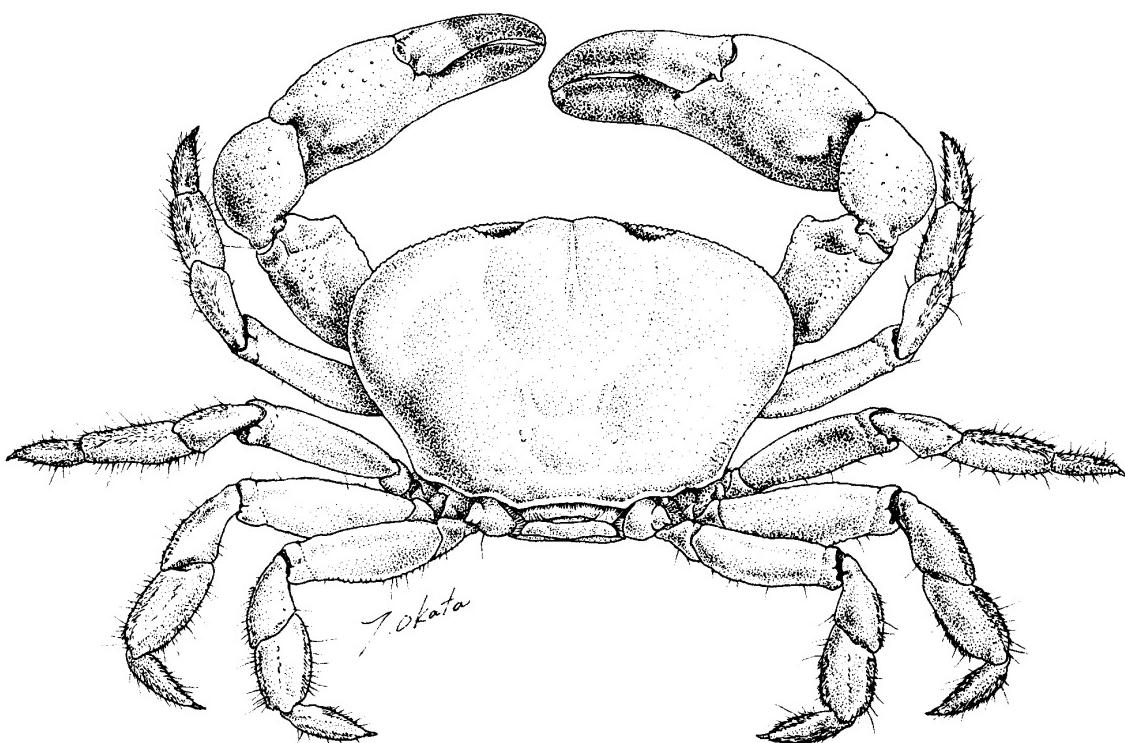


Fig. 3. *Austinograea yunohana* sp. nov., ♀ from Kaikata Seamount (paratype, NSMT-Cr 13658; 31.5×20.5 mm) in dorsal view.

larger (left) chela meet at distal one fourth, leave a narrow gape through their proximal three fourths, while in smaller (right) chela, fingers meet throughout their lengths; in larger chela, movable finger with two small, blunt teeth at its proximal part, immovable finger with a small conical tooth; in smaller chela, both fingers minutely dentate.

Ambulatory legs long, stout, depressed, being fringed with sparse longish setae and thick felt along posterior margins of meri and both margins of carpi, propodi and dactyli.

Abdomen with seven distinct segments, rather wide, not rapidly tapering; sixth segment provided with a deep pit at each anterolateral part of inner side, to which a wart-like granule of sixth sternite carrying the first ambulatory legs is just fitted to fasten the abdomen in natural position. First pleopod long, slender, reaching distal end of abdominal fossa, second pleopod filiform, as long as first pleopod.

*Notes on allotype* (Female: Fig. 7A). Biggest of all the specimens examined, with 50.5 mm in cb, 32.5 mm in cl., 0.64 in cl/cb; proportion of the carapace is almost the same with that of holotype male, but the carapace is seemingly wider and narrowed posteriorly because of the more strongly convergent and concave postero-lateral margins of both sides; left anterolateral margin of carapace weakly angulated

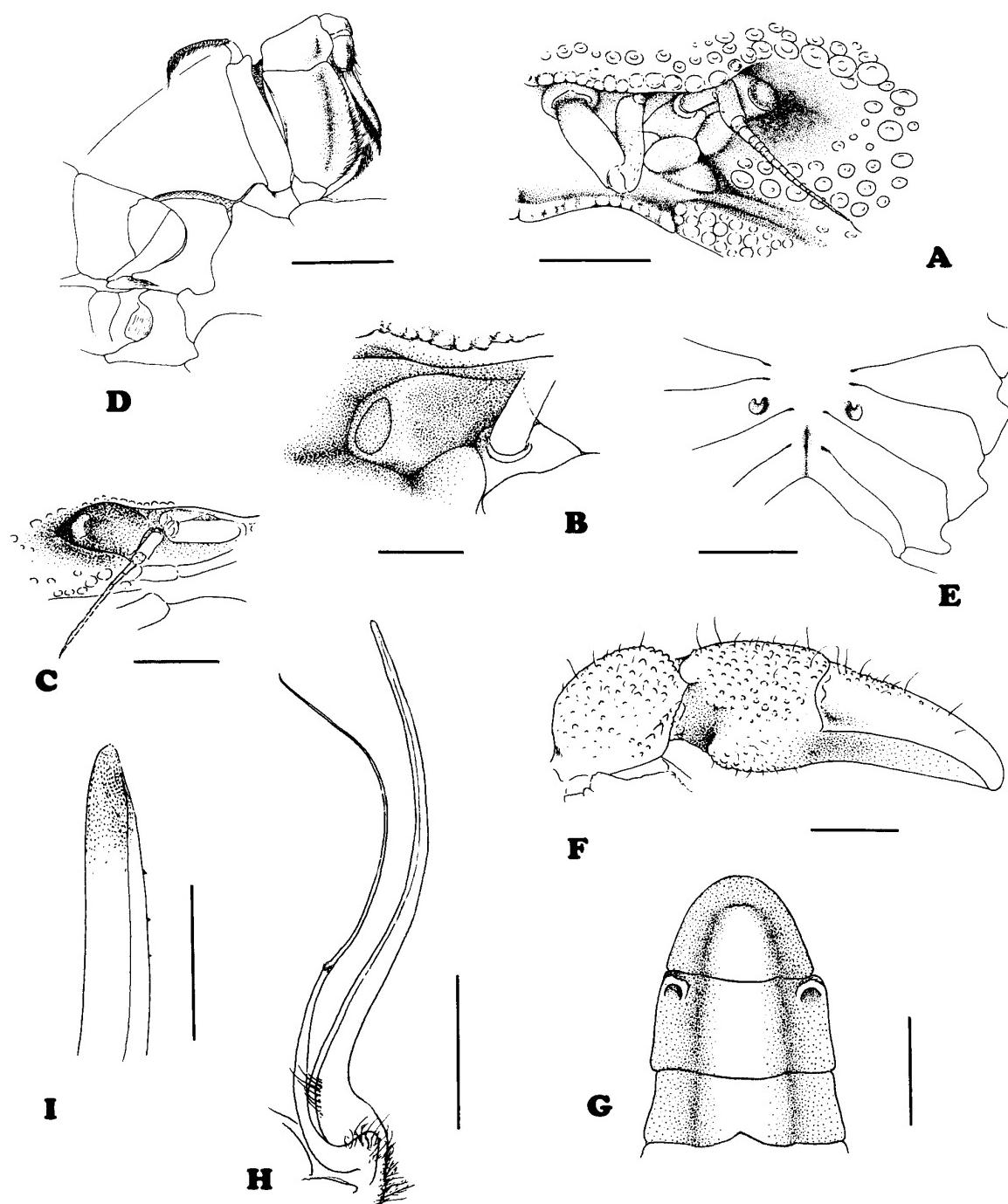


Fig. 4. *Austinograea yunohana* sp. nov., paratypes (A, B, NSMT-Cr 13657; D, E, NSMT-Cr 13658) and juvenile male (NSMT-Cr 13661) (C, F) from Kaikata Seamount, and holotype male from Myojin Knoll (NSMT-Cr 13655) (G-I). Frontorbital region (A-C), third maxilliped and pterygostomian region (D), sternum (E), right chela (F), distal three segments of male abdomen in inner view (G), first and second male pleopods in ventral view (H), and distal part of first male pleopod (I). A, ♂ (cb 27.0 mm); B, ♂ (cb 20.6 mm); C, F, juvenile male (cb 5.4 mm); D, E, ♀ (cb 34.4 mm); G-I, ♂ (cb 41.9 mm). Scales for A=2 mm; B, C, F=1 mm; D, E, G=5 mm; H=4 mm; I=0.5 mm.



Fig. 5. *Austinograea yunohana* sp. nov., both chelae of ♂ (paratype, NSMT-Cr 13657; cb 20.6 mm) from Kaikata Seamount, in outer and upper views, respectively. Scale=1 cm.

at posterior one third, but this is not indicative of the vestigial tooth.

Chelipeds heavy, slightly dimorphic just like and not much different from those of holotype male; merus shorter, main part disguised under anterolateral margin of carapace; fingers of larger (right) chela leave a narrow gape, with some conical teeth along cutting edges; two teeth of movable finger and one of immovable finger corresponding to those of the holotype male are more prominent than the others; colored part of fingers weakly swollen and raised.

Abdomen seven-segmented, covering whole sternal surface, but not circular in outline, with lateral margins from fourth to median part of sixth segments being parallel to each other. Genital opening big, with an overhanging knobbed tubercle from anterior edge.

*Notes on paratypes* (Adult males and females: Figs. 3, 4A, B, D, E, 5, 6). Eleven specimens in all, 6♂♂ (20.6×13.6 mm–38.0×24.9 mm), 5♀♀ (31.5×20.5 mm–38.3×25.2 mm), cl/cb ratio being 0.65–0.67 in both sexes. The general formation of the carapace, chelipeds and ambulatory legs agrees well with those of the male holotype and female allotype; the proportion of the carapace is quite constant, with the evenly convex and weakly granulated dorsal surface; each anterolateral border of the carapace is regularly convex, without indication of teeth or lobes. The orbit and eyestalk are typical for this species; the orbit is a transverse cavity, with the flattened anterior and posterior floors, just like in the holotype and allotype; the eyestalks are somewhat variable in size, growing thicker distally, and convex ventrally in some specimens, although the eyestalks are completely fixed and immovable in all the paratype specimens.

Both chelipeds are dimorphic distinctly in male and slightly in females, longer and heavier in male like in the holotype and allotype; four of six males and four of five females are right-handed; dentition of the fingers is fairly constant, although the fingers are heavily worn down in some specimens, with the blunt cutting or grasping edges and tips.

*Notes on additional specimens* (Small specimens: Fig. 4C, F). Twelve specimens in all, 11♂♂ (5.4×4.0 mm, 6.4×4.6 mm–16.3×11.0 mm, 17.3×11.7 mm), 1♀ (12.4×8.6 mm), cl/cb ratio being 0.68–0.69 except for the smallest two specimens in which the ratio is 0.72 and 0.74. In the biggest male, the first and second pleopods seem to be fully grown, but the second biggest male has the flexible pleopods in spite of their enough lengths, with their tips only rounded. There may be a critical size for the sexual maturity around this size. In general, these specimens have the carapaces narrower than in the adult specimens, as shown by the difference in the cl/cb ratio (0.68–0.69 in the small specimens versus 0.64 in the holotype and allotype, and 0.65–0.67 in the paratypes). In the smallest two males in which the first and second pleopods are very short, the carapaces are apparently narrower, with frontorbital and anterolateral margins fringed with minute, sharp granules.

In these specimens the carapace appears to be very close to that of the adult specimens except for the proportional differences; in some specimens the anterolateral margins are narrowly rimmed with sharp granules. In most of the specimens the orbit is shallower than in the adult specimens, and distinctly edged and delimited from the orbital floor along the lower margin of the eyestalk; the eyestalk is thicker than in the adult specimens, with the truncated cornea, and sometimes seen partly from above, although fixed and immovable even in the smaller specimens.

Even in the 7.4 mm young male in which the first pleopod is still very short, ca. 1/3 as long as the abdominal trench, both chelipeds are different in size and shape, but covered with small, somewhat scaly granules and scant short hairs. The proximal part of inner surface of the palm is convex, but not so sharply angulated as in the adult chelae. The male abdomens of these young specimens are not much different from those of the adult specimens, having a pair of buttons at sixth sternite.

*Remarks.* In establishing a new genus *Austinograea* based on a new species *A. williamsi*, Hessler and Martin (1980) mentioned the characters of generic importance in the family Bythograeidae, and referred three characters to the new genus, viz., 1) eyestalk is absent or merely fused portion of the orbital wall, 2) posterolateral extension of the coxa of the third maxilliped is entirely inserted to the gill chamber so as to be not seen in ventral view, and 3) male first pleopod is relatively straight and not twisted, and the second pleopod is distinctly shorter than the first. Additional one more character, the movable finger with the recessed ventral border bearing dense setae, was also put into the key to distinguish the new genus from three known genera, *Bythograea*, *Cyanograea* and *Segonzacia*.

In *A. alayseae* described by Guinot (1990) as the second species of *Austino-*

*graea*, the eyestalk is firmly fixed to orbital floor, but its distal part is more or less thickened and raised, distinctly different from the condition seen in the type species, *A. williamsi*, and very close to the case of the new species just described, *A. yunohana*. In *A. alayseae* as well as *A. yunohana*, the smaller chela (the so-called cutter) is, even in the smaller males, not so sharply toothed, on the cutting edges as in *A. williamsi*, without setae on the inner surface of the movable finger. Accordingly the presence or absence of the setae on the movable finger is subjected to the specific level.

In both of *A. williamsi* and *A. alayseae*, the male second pleopods are about half the length of the first, having a small, oval field fringed with wrinkled setae at one third distinct from the whippy tip (Hessler & Martin, 1989; Guinot, 1990; Tsuchida & Fujikura, 2000). In *A. yunohana*, however, the male second pleopod is apparently longer than those of these two species, and nearly as long as, or only slightly shorter than, the first, with the whip being as long as the grip (Figs. 4a, 5b). In general, as already mentioned by Guinot (1990), the length of the male second pleopods are of phylogenetic importance at the generic or even familial ranks, as in the cases of the genera *Globopilumnus* Balss of the Menippidae and *Pilumnoides* Lucas of the family Xanthidae (Guinot-Dumortier, 1960; Guinot & Macpherson, 1987). At least, regarding the length of the male second pleopod, it is definitely said that the new species described in this paper, in which the male second pleopod is distinctly longer than half the length of the first, but does not exceed the tip of the first, is within the range of a same genus with the two species described previously, in which the male second pleopod of each species is about half the length of the first. *Austinograea williamsi* Hessler et Martin is specifically quite distinctive in the depressed body, the completely degenerated eyes and eyestalks, the dimorphic male chelipeds having the merus armed with a series of spines on the anterior margin, the deep immovable finger, two or three prominent spiniform teeth interspersed by some smaller teeth on the cutting edges of the immovable finger, and the dense setae on the inner side of the chela.

The new species, *A. yunohana*, is without doubt close to *A. alayseae* than to *A. williamsi* in the general formation of the carapace, the degenerate condition of the eyestalk, and the shape of the chelipeds. The proportional ratio of length and width of the carapace is nearly the same in the new species and *A. alayseae*, but in the new species the posterolateral margin of the carapace is more strongly convergent toward the posterior margin of the carapace and rather concave at its median part, with the posterolateral surface being rather strongly concave. In *A. alayseae* the sixth segment of the male abdomen is one and half as long as the fifth segment, and there is a cavity at distal part of the abdominal trench, while in the new species the sixth segment is equal in length to the fifth segment, and there is no cavity in the abdominal trench at the place corresponding to the cavity of *A. alayseae*. The male first pleopod is almost unarmed in the new species, but strongly armed with spiniform setae along the margins for whole length in *A. alayseae*. Otherwise, as mentioned above, in the new

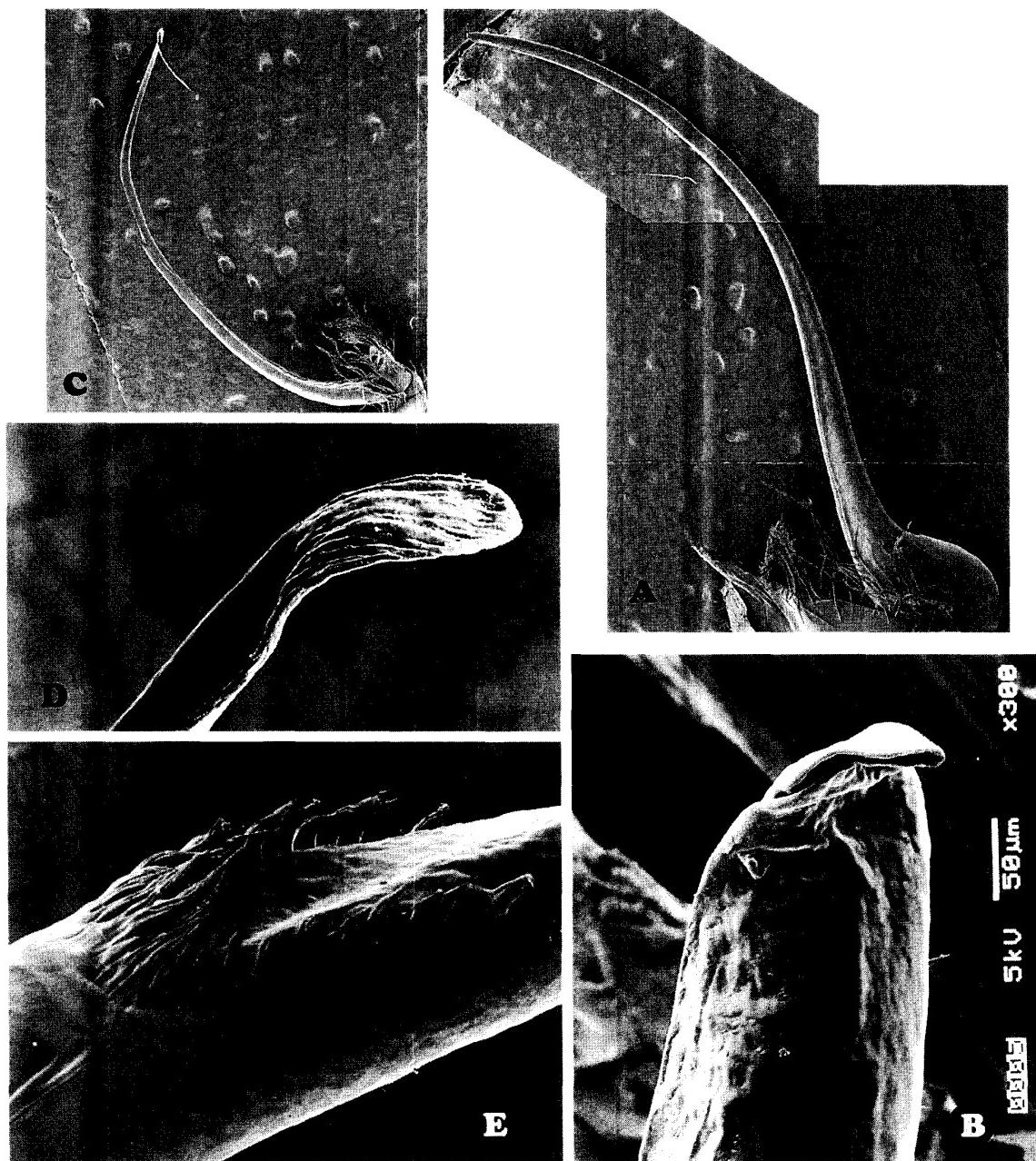


Fig. 6. *Austinograea yunohana* sp. nov. SEM photograph of left first (A, B) and second (C-E) pleopods of ♂ (cb 33.8 mm) from Kaikata Seamount. Scale for B is also applied to D and E.

species the male second pleopod is filiform and nearly as long as the first, differing from that of *A. alayseae* in which the second pleopod is nearly half the length of the first. It is apparent that this difference in the comparative length of the male second pleopod is quite distinctive and not dependent on the individual or developmental variations. The holotype male and allotype female of *A. alayseae* are 16×24 mm and 21×32 mm in size, respectively, although the original author designated many, much

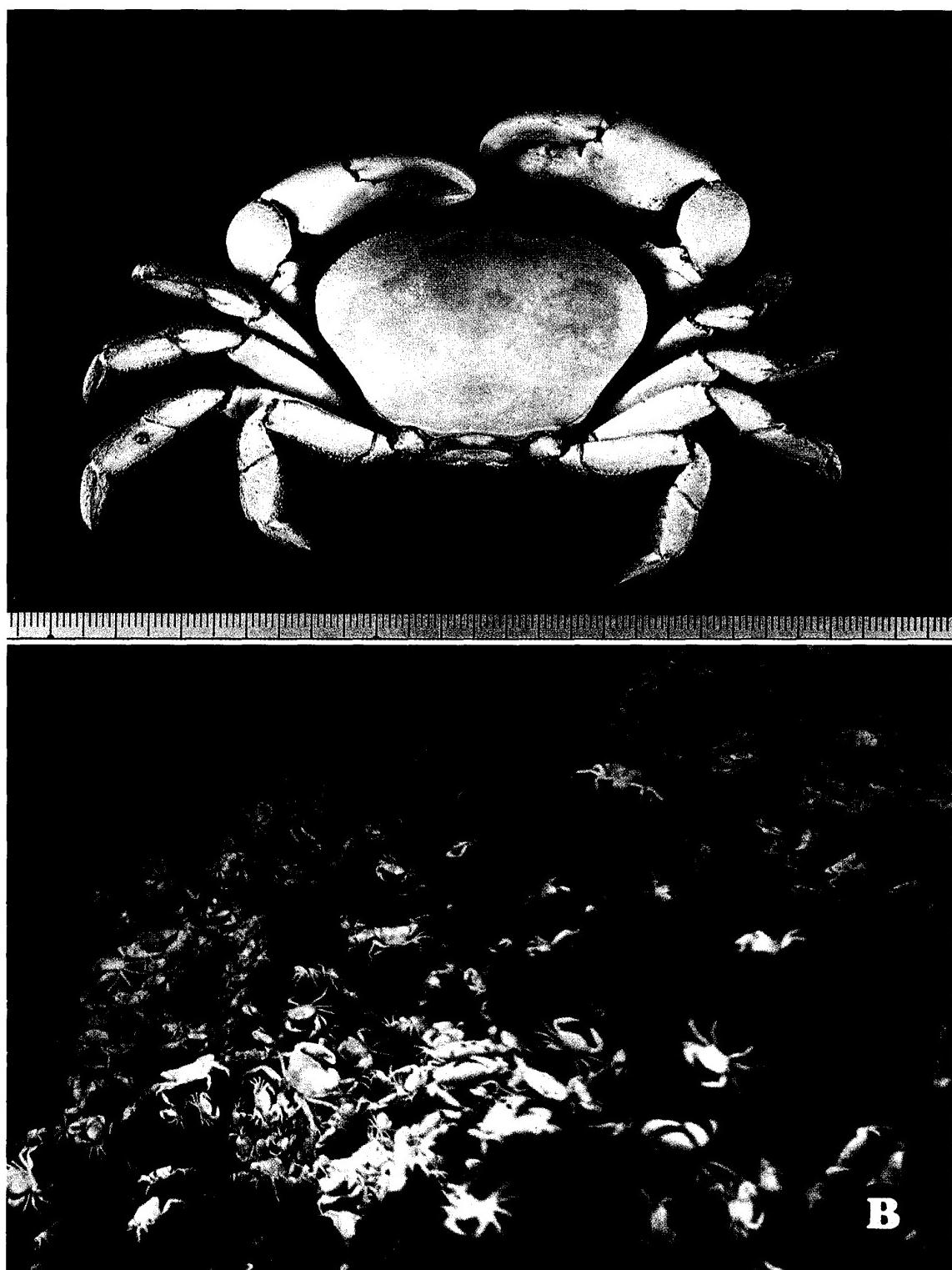


Fig. 7. *Austinograea yunohana* sp. nov., ♀, allotype (NSMT-Cr 13656) (A) from Suiyo Seamount, in dorsal view, and a scene at hydrothermal vent on Kaikata Seamount (B). Scale for A in mm.

bigger specimens as the paratypes in the addenda at the end of the paper. In the rather small males ( $11.0 \times 16.3$  mm and  $11.8 \times 17.3$  mm) of the new species which are much smaller than the holotype male of *A. alayseae*, the male second pleopods are well developed and as long as the first. Even in the smaller males ( $8.4 \times 12.5$  mm and  $8.3 \times 12.3$  mm), the second pleopods are longer than half the length of the first, each having the semitransparent fragile shaft and incomplete tip of the whip.

The generic definition of the genus *Austinograea* was partly to be changed to accommodate the second species, *A. alayseae*, viz., the eyestalk being completely degenerated without cornea, or vestigial and fixed, with unpigmented cornea, and the dense setae on the inner surface of the chela being of no generic importance. At present, a further change to accommodate the third species, *A. yunohana*, is obliged to male as follows: The male second pleopod is as long as, or longer than half the length of, at most nearly equal to, the first.

**Etymology.** Numerous whitish crabs covering the rocks around the hydrothermal vents look like sulfurous sediments from hot spring water, which are named yunohana (flower of sulfur) in Japanese. Its specific name is used as a noun in apposition. The Japanese name is Yunohana-gani.

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